Furniture Mock-up Performance
Under California Technical Bulletin 133 Test Conditions

T. Ohlemiller and J. Shields
Building and Fire Research Laboratory
National Institute of Standards and Technology

Introduction

Fires involving soft furnishings such as upholstered chairs and mattresses continue to play a prominent role in U. S. fire losses. This is a multi-faceted problem that has been addressed, over the years, from several directions with some significant success. Fire deaths and injuries involving these products show a substantial decline over the past 15 years. One of the more recent developments in this area is the increasing acceptance of a test protocol (CB 133) developed at the California Bureau of Home Furnishings, intended for upholstered chairs utilized in public occupancies (hotels, hospitals, etc.). The protocol imposes quite restrictive limits on the response of a chair (or equivalent mock-up) to an arson-like ignition source (an 18 kW gas burner). Of particular interest here is the rate of heat release response to burner exposure since this effectively measures the size and threat of the resulting fire.

Imposition of CB 133 requirements poses a substantial challenge to the furniture industry, given the enormous variety of fabrics and chair styles employs. There is a strong interest in the potential use of small-scale tests, such as rate of heat release measurement in the Cone Calorimeter, as predictors of full-scale behavior. The relation, for a variety of material combinations, between behavior in the Cone Calorimeter and in full-scale chair mock-ups is one facet of the present study. A major approach employed by the industry in attempting to pass the CB 133 requirements involves the use of a barrier layer of material enclosing the polyurethane cushioning. These barriers are not always successful in limiting the size of the fire. An examination of the mode of failure of these barriers is another facet of the current work.

Experimental

Seven fabrics, four barriers and two polyurethane foams were examined in tests of 27 material combinations. Full-scale mock-ups having four cushions (seat, back, two arms) were tested in the NIST Furniture Calorimeter to ascertain the rate of heat release as a function of time, during and after the standard 80 second exposure to the gas burner in the seat area. Five of the tests were replicated. Extensive visual documentation was utilized. In addition, two heat flux gages were placed on the seat area to measure the local flux history involved in fire development.

Cone Calorimeter tests were run in triplicate on all of the material combinations at the nominally standard external flux of 35 kW/m^2. Heat release rate behavior as a function of incident radiant flux was measured for three of the material combinations and one barrier/foam combination without a fabric on top. Lateral flame spread behavior of some of the material combinations was available from a previous study.

Results and Discussion

The full-scale tests frequently resulted in two rate of heat release peaks. The first typically came near the end of the gas burner exposure; the second, when it was significant, followed much later and was often higher, signifying failure of the barrier to stop progression of the fire to the point of substantial involvement of the polyurethane in the cushions. The first peak appeared to be dominated by the fabric behavior but that behavior was often quite complex, involving macroscopic movements of appreciable quantities of fabric melt on the chair surfaces. The second peak appeared to be the result of a single failure mechanism which involved the development of a self-feeding, polyurethane melt fire at the bottom of one or more of the cushions. Sufficient heat was transferred from the upwardly buoyant flames, through the intact barrier, to the foam inside so as to cause a continual flow of fuel (polyurethane melt) to the flames. Such fires were sometimes able to grow and achieve heat output peaks of up to several hundred kilowatts, depending on the fabric and barrier.

Figure 1 shows a plot of the value of the first peak of heat release in the full-scale tests versus the averaged behavior for a period of 60 seconds after ignition in the Cone Calorimeter (at 35 kW/m^2). Note that the units on the two axes differ; the ordinate is not per unit area. The various symbols pertain to differing fabric and foam combinations; where the same symbol recurs, the only difference is the barrier. There clearly is a tendency for the full-scale behavior to follow the small-scale behavior. However, the uncertainty in the relationship is obviously large, making it doubtful that this relation has practical use. The sources of this variability are under study as is the possibility of other simple relationships between small-scale and full-scale behavior.

FIG. 1 CORRELATION BETWEEN CONE RHR AND FIRST FULL SCALE RHR PEAK